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(54) DIAPER HAVING IMPROVED SURFACE DRYNESS

(71) We, THE PROCTER & GAMBLE COMPANY, a corporation organised and existing under the laws of the State of Ohio, United States of America, of 301 East Sixth Street, Cincinnati, Ohio 45202, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to diapers of the type having a topsheet adapted to be placed adjacent an infant's skin and an absorbent substrate to absorb waste fluids from the infant.

Diapers comprising a porous hydrophobic topsheet and a hydrophilic substrate are well known. The purpose of the combination is to reduce the amount of moisture in contact with the wearer's skin and thus reduce skin maceration, diaper rash and other unpleasantness. It should be recognized that the terms "hydrophobic" and "hydrophilic" as herein employed, while useful in their brevity actually refer, respectively, to relatively low and relatively high critical surface tensions of the materials being characterized. The hydrophobic nature of a diaper topsheet is clearly evidenced by its lack of affinity for liquid human waste relatively to that of the hydrophilic or absorbent substrate and as used herein a web is hydrophobic when a drop of liquid waste placed thereon does not spread to any appreciable degree on the web. In this respect, the threshold of hydrophobicity of a diapering material is in the vicinity of about 40 to 50 dynes per centimeter at 20°C. Thus, when a hydrophobic sheet is superimposed upon a layer of hydrophilic or less hydrophobic absorbent material to form a diaper and the hydrophobic sheet is placed next to the wearer's skin, waste fluids from the wearer pass through the hydrophobic sheet and are preferentially partitioned by and absorbed within the underlying hydrophilic layer, leaving the topsheet adjacent the wearer's skin relatively dry.

Efficacy of the above-described materials' combination is limited, however, and surface wetness remains a problem. Surface wetness of the hydrophobic topsheet in the center portion of the diaper is believed to result from inefficient transfer of waste fluids from the center section into the other portions of absorbent material and, when the diaper is worn by an infant, from repeated compression of the absorbent material in the front and central areas of the diaper due to stresses caused by the movement of the infant's thighs, the compresive stresses squeezing fluid out of the absorbent substrate and causing consequent flooding of the upper surface of the topsheet i.e. that surface which comes into contact with the infant's skin. This flooding is followed by decompression of the absorbent material and slow reabsorption of the fluid. As used herein the terms "flooding" and "reflooding" are synonymous and connote the wetting of the upper surface of the diaper topsheet with waste fluids which were previously absorbed in the absorptive substrate.

Excessive wetness of the skin at the base of the infant's trunk tends to macerate the skin and thereby reduce its natural resistance to primary irritants present in or derived from the infant's waste products. In this respect, even if the surface of a diaper is damp (as it would be if a hydophilic topsheet were used) it is advantageous to eliminate, to any extent possible, the flooding of the diaper topsheet upper surface. Where this maceration problem has been recognized in diaper design, the counter measures involve concentrating absorptive materials in the central portion or along a longitudinal centerline of the diaper. This common-sense approach, "putting the absorptive material where it is needed most," is old in the art, honored frequently in practice, and yet does not solve the problem of skin wetness caused by flooding at the center of the diaper.

In view of the above-recited shortcomings, it is desirable therefore, to provide a diaper structure which reduces the surface wetness problem and which precludes repeated flooding of the upper surface of the topsheet.

According to the present invention there is

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provided a diaper comprising a topsheet for placing adjacent an infant's skin, an absorbent body having a length and width enabling it to be applied to the lower portion of the torso of a child, said absorbent body having end sections adaptable to embrace the waist and cover adjacent abdominal and back areas of the child and a central section adaptable to lie between the child's legs substantially throughout their normal range of movement, said absorbent body being continuous throughout its length and having, throughout a portion of its central section extending over at least 70% of the width of the absorbent body, an average unstressed absorptive capacity per unit face area which is lower than the average unstressed absorptive capacity per unit face area in other portions of said absorbent body.

A further particular embodiment of the invention comprises the diaper described above wherein the compression of the absorbent body under stress due to the infant's activity causes a change in absorptive capacity per unit face area of the absorbent body in the interior of the central portion which is exceeded by the free space available for fluid retention per unit area of a hydrophobic topsheet under equal stress.

According to a specific feature of the present invention there is provided a diaper having a length and width adapted to be applied to the lower portion of the torso of a child, said diaper having end sections adapted to embrace the waist and cover adjacent abdominal and the back areas of the child and a central section adapted to lie between the child's legs substantially throughout their normal range of movement, said diaper comprising a pad formed into a box pleat configuration by means of a multiplicity of longitudinal folds, said folds being unsecured at the ends of said paid whereby the pad is freely laterally spreadable at said ends, said box pleat configuration including a central panel, a pair of oppositely disposed inside panels connected to the sides of said central panel and folded in non-overlapping relationship with one another over one face of said central panel with inner sides of said inside panels justaposed, and a pair of outwardly facing treminal panels overlying said inside panels, each of said terminal panels having an outer side edge which comprises a free edge of said pad; said pad being continuous from end to end and comprising an absorbent body, a porous topsheet overlying one major surface of the absorbent body and secured thereto, said absorbent body having in the interior of its central section an average unstressed capacity per unit face area which is lower than the average unstressed absorptive capacity per unit face area in other portions of said absorbent body, said interior of said central section comprising at least 70% of the width of said absorbent body; said diaper including a thin waterproof back sheet on the side of the absorbent body which is remote from said topsheet, which back sheet has a width exceeding that of the said pad so as to provide oppositely-disposed side flaps which are folded inwardly to enclose the side edges of said pad and overlie a portion of said terminal panels.

Specific embodiments of diaper construction and other features of the invention are illustrated in the accompanying drawings in which the thickness of some of the materials are exaggerated for clarity and in which:

Figure 1 is a perspective view of a diaper of the present invention, partially broken away to show details of construction.

Figure 2 is a perspective view showing the form which the diaper of Figure 1 assumes in use;

Figure 3 is a section view taken along lines 3—3 of Figure 2;

Figure 4 is a diagrammatic view of a test apparatus;

Figure 5 is a longitudinal sectional view taken along the line 5—5 of Figure 1;

Figure 6 is a lateral sectional view taken along the line 6—6 of Figure 5;

Figure 7 is a longitudinal sectional view similar to Figure 5 and showing an alternate construction;

Figure 8 is a longitudinal sectional view of a further embodiment of this invention;

Figure 9 is an end view of the diaper of Figure 8 after it has been prefolded into a box pleat structure;

Figure 10 is a plan view of the prefolded diaper of Figure 9; and

Figure 11 is a perspective view of a transverse cross section through the central portion of the prefolded diaper of Figures 8—10 showing the approximate shape it takes preparatory for use.

Referring to the drawings, Figure 1 illustrates a diaper embodying the subject of this invention. The diaper has a pad 19 comprising a body or substrate 20 of absorbent materials and an overlying layer or topsheet 21. This diaper has a length and width adapted to enclose the lower portion of the torso of a child, with end sections adapted to embrace the waist and cover adjacent abdominal and back areas of the child. An optional waterproof back sheet 22 is shown which can be made of, for example, a thin plastic film of polyethylene, polypropylene, poyvinylchloride, or other suitable flexible material. (The waterproof back sheet is not necessary to the practice of this invention inasmuch as the diaper comprising the absorbent body or substrate 20 and the overlying topsheet 21 can be used in conjunction with a separate pair of waterproof pants to protect infants' clothing; however, the backsheet 22 is particularly advantageous when used with a diaper of the type shown in Figure 1 which has been prefolded to the configuration of Figures 9—11, hereafter explained.)

The central section 23 of body 20 has, at least in its interior, a substantially uniform absorptive capacity per unit face area which is lower than that of the contiguous absorbent body material, which can be achieved by providing a central section 23 which is thinner than the continguous absorbent body material as shown in Figure 1. Preferably, the layer of topsheet 21 is hydrophobic and subsequent description assumes this is the case. Provision of a relatively low absorptive capacity central section 23, alone or in combination with the hydrophobic topsheet 21, facilitates wicking of an infant's liquid discharge to the diaper's extremities and results in a drier surface adjacent the infan'ts skin than occurs with a diaper having the combination of a hydrophobic topsheet and an absorptive pad which is substantially uniform in absorptive capacity throughout its length and width or, alternatively, has a greater absorptive capacity in its central section than in its extremities. While the reasons for this result are not fully understood, it is believed that the lower absorptive capacity central section 23 may act as a saturated source of moisture during and immediately after the infant's urinal discharge to provide a relatively large moisture gradient relative to the diaper extremities, thus providing a larger driving force for wicking to the diaper's extremities than occurs in the other described types of diaper. Within a short time, this gradient becomes reduced through the mechanism of mass transfer to the diaper's extremities and results in a lower total moisture content within the diaper's central section 23 than would otherwise occur.

Figure 2 illustrates the diaper of Figure 1 in the form in which it appears in use, including leg openings 24 defined when the diaper is secured to an infant, and side portions 22a of back sheet 22 which are folded inwardly over the side of the absorbent pad 19.

Figure 3 illustrates the diaper of Figure 2 in section and shows the placement of the thin central section 23. The section 23 is full width of the body 20 and located so that it lies between the infant's legs when they are in any of several positions within the normal range of his activity. In this connection, preferable practice places the section 23 so that it extends on the diaper in use from about 120° forward of the intersection of a horizontal line forming the leg opening centres and the vertical center line of the (angle A) to about 45° rearward thereof. It may be desirable, however, from the consumer's point of view, to center the central section 23 lengthwise of the pad to avoid confusion between the front and rear of the diaper. In this event, central section 23 can encompass the angle extending from about 120° forward of the vertical center line of the leg opening 24 to about 120° rearward thereof (angle B). Thus, the thin central section 23 encompasses the locus of the infant's urinal discharge and only the thin central section 23 is subjected to repeated compression and decompression by movements of the infant's legs. This has been found to highly alleviate diaper surface reflooding when combined with certain limitations (detailed below) in the variation in available free space for fluid retention (i.e., absorptive capacity) in section 23 and the overlying portions of topsheet 21, if hydrophobic, with changing compressive stresses caused by an infant's activity.

With repect to absorbency properties, although section 23 is preferably uniform in absorptive capacity throughout its width, this does not necessarily have to be the case. All that is required to result in a diaper substantially improved with respect to overall effectiveness, fit, comfort and resistance to reflooding is that the abrsorptive capacity per unit of surface area of at least the interior of section 23 be measurably and uniformly less than the average absorptive capacity per unit of surface area in other portions of the diaper. Thus, instead of section 23 being thin throughout its breadth, it could be thin in the center and have a full thickness strip at each side. In this case each of the side strips should not exceed 15% of the total width of section 23 so that the thin interior thereof, i.e., the area between the strips, is at least 70% of the full width of the central section in order to result in a meaningful improvement. Preferably the absorptive capacity per unit of face area in the interior of section 23 should be at least about 10% lower than that in other portions of the diaper.

In use, central section 23 of the diaper assumes a certain state of compression with a given position of the infant's legs. This compression is reflected in the free space of the central section 23 of the absorbent body 29 relative to the free space of the portions of the hydrophobic topsheet 21 which overlie section 23. Upon the infant's flooding of the diaper with waste fluids, the fluid will pass through the hydrophobic topsheet 21, saturate or nearly saturate the central section 23, and migrate by wicking toward the extremities of the diaper. Within a short time, the bulk of the fluid will be absorbed, leaving a relatively dry upper surface of the hydrophobic topsheet adjacent the infant's trunk. Subsequently, the normal activity of the infant will cause the absorbent material in section 23 to become compressed, thereby causing a reduction in free space available for obsorption, and hence, in fluid retention or absorptive capacity. The fluid displaced by this compression will migrate back into the free space within the hydrophobic topsheet 21, and, if of sufficient volume, will reflood the upper surface of the hydrophobic topsheet 21. If, however, the weight of absorptive substrate which is subjected to the compression, when multiplied by the differential volumetric moisture content per unit of weight

of absorbent material between unstressed and stressed conditions, is lower than the free space available for fluid retention for overlying portions of the topsheet 21, flooding will be avoided.

The stresses to which the central section 23 of a diaper will be subjected are equivalent to a range of from about 0.1 to about 6 pounds per square inch applied uniformly to a rectangular sample of hydrophilic or hydrophobic material, with a range of about 0.5 to 3.0 p.s.i. encompassing most in-use stresses encountered. One method determining the relevant absorptive capacity parameters of diaper materials is to place a saturated sample 25 of material on a slight (e.g., 10°) incline 20 as shown in Figure 4 and place varying weights 27 on its top surface as shown. Knowing the size of the sample 25, the dry weight, the saturated weight, and the weight of the sample after subjection to the compressive stress indicated, one can determine the unstressed absorptive capacity and the change in absorptive capacity of the material under stress per unit of weight, or, if desired, per unit face area of the material. Examples of test results obtained with some hydrophilic and hydrophobic materials are tabulated below.

Sample	Sample No.	No. Plies	Sample Area	Absorptive Capacity[1]) for Indicated Sequential Compressing Operations					Change in Average Absorptive[2]) Capacity over Design Stress Range	
				0 psi	1 psi	0 psi	3 psi	0 psi	0 psi—1 psi	0 psi—3 psi
Calendered and Embossed Airfelt made from southern kraft fibers (Foley fluff) and having a weight of 3 grams.	1		9 in.^{2}	20.6	8.3	13.1	5.1	12.4		
	2		9 in.^{2}	20.3	8.2	14.5	5.7	12.5		
	Avg.			20.4	8.2	13.8	5.4	12.4	5.6	7.0
Embossed creped cellulose wadding — 8 plies having a basis weight (air-dry) of 24—28#/3000 ft.^{2} after creping	1	8	9 in.^{2}	16.9	6.7	12.6	4.4	11.1		
	2	8	9 in.^{2}	16.3	6.3	12.6	4/2	11.6		
	Avg.			16.6	6.5	12.6	4.3	11.4	6.1	7.1
Topsheet wet laid sheet comprising rayon, manila and kraft fibers bonded with latex binder (available from C H Dexter and Sons, Company, Windsor Locks, Conn., and identified as X—1496) [3])	1	13	9 in.^{2}	No valid data-sample did not wet without pressure being applied		7.2	3.6	7.3		
	2	13	9 in.^{2}			7.2	3.7	7.4		
	Avg.					7.2	3.6	7.4	about 3.6	3.8

[1]) g H_2O/g. dry absorptive material.

[2]) g H_2O/g. dry absorptive material — this is the change in average absorptive capacity from the 1 psi or 3 psi value to the 0 psi value after initial compression to the indicated high pressure of the range (i.e., the 1 psi and the 3 psi values). This will reflect in-use conditions because a certain amount of precompression will take place contemporaneous with and soon after the diaper is applied to an infant.

[3]) Basis weight of about 15#/3000 ft.^{2}.

Given the results tabulated above, or results similarly obtained for materials not included in the above list, one can then determine a workable combination of materials in which the absorptive capacity of the hydrophobic topsheet material under maximum design stress (e.g., 3.0 psi) is sufficient to contain an appreciable amount of the fluid contained in the central section 23 which tends to reflood the surface of topsheet 21 when the diaper is subjected to compression encompassing the design stress range (e.g., 0.5 to 3.0 psi). For example, in a diaper having a single ply topsheet as described in the tabulation above and a central section 23 consisting of a single ply of the cellulose wadding described therein, roughly one-third of the fluids squeezed out of section 23 by a 3 psi stress would be retained in the interstices of the topsheet 21. As an ultimate, a 4 ply topsheet 21 of the material described combined with a single ply creped cellulose material central section 23 would preclude surface reflooding altogether. Alternatively, a 6—8# basis weight tissue underlying a single ply of topsheet would also preclude flooding.

Figures 5 and 6 illustrate in section the manner in which the thin central section 23 can be provided. The hydrophilic layer comprises a body 20 of compressible absorptive material which is initially of substantially uniform thickness and in which the thinner central section 23 has been provided by locally compressing the body 20 beyond its elastic limit to a fraction of its uncompressed thickness. One material which is readily adaptable to this construction and is suitable for a disposable diaper is creped cellulose wadding. Alternatively, the material can comprise an airfelt made of air-laid pulp fibers, or a mixture of airfelt and creped wadding. The body 20, when made of creped cellulose wadding will perform satisfactorily consistent with cost limitations when it comprises plies of wadding having a combined basis weight (air dry) of 120—240 pounds per ream of 3000 square feet after creping. Since increasing the free space and thus the absorptive capacity per pound of paper under moderate stress is desirable, the plies of wadding are preferably highly creped, i.e., about 45% to 70% crepe—the crepe being equal to one hundred times the quotient of the reduction in length caused by the creping of a piece of tissue divided by the length of the piece of tissue in its initial uncreped form. The thin central section 23 can be formed in the body 20 described above by locally compressing the wadding (by equipment and techniques readily apparent to those skilled in the art) beyond its elastic limit and to a point where the free space content is approximately 85% to 95% of the total volume of the wadding. In this condition, the change in fluid retention capacity of the body 20 in the thin section 23 over the aforementioned stress range of 0.5 to 3 psi will range from 4 to 12 cubic centimeters per gram of absorptive substrate (of a specific gravity of 1.5). If the free space content exceeds 95%, too much moisture will be absorbed therein and causes reflooding problems; if it is much less than about 85%, the material tends to stiffen and become undesirable from a comfort standpoint. The approximate free space content of a fibrous mass can be determined experimentally by measuring the dry weight in grams of a sample (W_d), the weight in grams of the sample saturated with water (W_s) and using the following formula in which S.G. is the specific gravity, of the material comprising the fibers (for example, cellulose has a S.G. of about 1.5):

$$\text{percent free space} = \frac{W_s - W_d}{\dfrac{W_d}{S.G.} + (W_s - W_d)} \times 100 .$$

The length and placement of section 23, as noted above in connection with the description of Figure 3, should be such that it extends over a sufficient area to allow for the normal range of activity of an infant's legs when the diaper is in use. A diaper having the construction described above can, for example, have an overall lengthwise body 20 dimension of 16 inches and, as shown in Figure 5, the length L of central section 23 can comprise about 30—45% of this dimension, i.e., about 5 to 7 inches. In the case described, section 23 can be placed a dimension M of from about 2 to about 4 inches from the front 28 of the body 20.

A topsheet 21 which when combined with the creped cellulose wadding described above will retain an appreciable quantity of the fluids tending to reflood its upper surface when the diaper is stressed can comprise, for example, a nonwoven sheet made of 0.75 to 3 denier rayon, 1⅞" long, staple containing approximately 20—35% thermoplastic binder (as, for example, copolymers of an ester of acrylic acid such as is sold by the Rohm and Haas Company and identified as HA—8 and/or HA—24), and having a weight of about 15—24 grams per square yard. For best results in processing such a sheet, surfactants should be minimal in the binder emulsion and avoided in the final bath. The topsheet 21 as described has an absorptive capacity, i.e., free space available for fluid retention, under design maximum in-use stresses of 3 pounds per square inch of 3—4 grams water per gram of topsheet.

The topsheet 21 in the embodiment described above can be secured to the absorbent body 20 in any convenient manner, for example, as shown in Figures 5 and 6. In Figure 5, the ends of the topsheet 21 are shown folded

under the absorbent body 20 and adhesively secured to the underside thereof at 29. Figure 6 illustrates how the longitudinal edges of top-sheet 21 are folded over the sides of the body 20 and adhesively secured at 30 to the under-side of the absorbent body. The adhesive applied along areas 29 and 30 is desirably only slowly soluble, if soluble at all, in water so as to avoid the danger of separation of the topsheet 21 from the body 20 in use.

The waterproof back sheet 22, when used, desirably comprises aa low density, opaque polyethylene web 0.7—1.5 mils thick which is adhesively united to the hydrophobic topsheet 21 along the underfolded portions thereof at 30a, as shown in Figure 6. In the preferred srtucture embodying this invention, which is described below in connection with Figures 8—11, the back sheet is preferably about 1″ to 4″ longer and about 2″ to 4″ wider than the absorbent body 20.

Figure 7 illustrates an alternative means for providing a thin central section 43. This alternative comprises making the absorbent body from a thin layer 31 of absorbent material which runs the length of the diaper and the thicker sections of absorbent body from one or more layers 32 of absorbent material secured to the layer 31 and topsheet 21 by sewing or other suitable means. Layers 31 and 32 can be different materials; for example, in a single use diaper, layer 31 can be a material having a relatively small capillary size and low compressibility under the 0.5 to 3 psi stresses hereinbefore described such as 10 pounds per 3,000 square feet basis weight Kraft tissue creped at 12—18%, and the layers 32 can be of relatively large capillary highly absorbent material such as airlaid felt or highly creped cellulose wadding, or mixtures thereof, without regard to the compressibility of layers 32 under the in-use stresses. An airlaid felt can comprise air-deposited pulp fibers, such as softwood papermaking fibres, or other suitable fibers capable of being formed into an absorptive structure, and the fibers can be lightly bonded, if desired, by a suitable adhesive such as starch, melamine formaldehyde or other bonding material. A hydrophobic topsheet 21, waterproof back sheet 22 and adhesive along areas 29, can be employed as described in connection with the embodiment of Figures 1—3, 5 and 6.

The same principle can be utilized in reusable diapers wherein the hydrophobic top-sheet of the diaper is of a material whose hydrophobic quality would be little affected by detergents used in washing. Materials suitable in this connection include open porous mesh fabrics made from Verel (Registered Trade Mark of Tennessee Eastman Co., Division of Eastman Kodak Co.), polypropylene and polyethylene overlying a cotton or cellulose acetate substrate. A reusable diaper of this type preferably would not include materials such as polyethylene for the back sheet because of the adverse effect that laundering has on such materials; polypropylene or other materials which are not affected by laundering might be used, however, or none at all.

The relatively low absorbency central diaper section can be provided by means other than thinning or compressing the absorptive substrate as described above. One such alternate structure is that shown in Figure 8. The Figure 8 structure illustrates an absorptive pad 33a which comprises an absorbent material or substrate 33 of substantially uniform thickness, a topsheet 34 which is preferably hydrophobic, and a water impervious insert 35. Additionally, a waterproof back sheet 36 can be optionally included for the purposes referred to above. The topsheet 34 and back sheet 36 can be made in the manner described with respect to the topsheet 21 and back sheet 22 of the embodiment of Figures 1—3, 5 and 6.

Insert 35 is made of a suitable water-impervious, thin, flexible film material similar to that of back sheet 22, as exemplified by 0.1—1.0 mil thick polyethylene or polypropylene, and extends the major portion of the width of substrate 33, i.e., at least about 70% of the width thereof. If insert 35 extends less than about 70% of the width of the substrate, the improvement derived therefrom is not pronounced. It is placed so that in use it extends over an area which allows for the normal range of activity of an infant's legs similarly to the placement of section 23 noted above in connection with Figure 3. A diaper having the Figure 8 construction can, for example, have an absorbent body 33 length of 16 inches, and the length L′ of insert 35 can comprise about 30—45% of this dimension, i.e., about 5 to 7 inches. In the case described, one end of the insert 35 can be placed a dimension M′ of from about 2 to about 4 inches from the front 37 of the diaper.

The vertical location of the insert 35 within substrate 33, i.e., with respect to the relative thicknesses of the portions of the substrate 33 above and below the insert 35, depends upon whether the objective to be accomplished is only to improve diaper surface dryness through improved wicking to the diaper extremities and partially alleviate the surface reflooding problem or whether the objective to be accomplished includes preclusion of substantially all surface reflooding mentioned above. Any vertical placement of the insert 35 which noticeably reduces the absorbency per unit face are of that portion of absorbent body 33 between insert 35 and topsheet 34 in comparison to its full thickness absorbency will promote wicking to the diaper extremities. For this purpose and width the absorptive materials previously described, insert 35 should be above the center of thickness of substrate 33 and, preferably, immediately below the top ply of absorptive wadding or tissue, if used,

or immediately below the top 2—20% of air-laid felt thickness, if this material is employed.

If the objective to be accomplished by the structure is preclusion of substantially all surface reflooding, the vertical placement of insert 35 should consider the relative absorptive capacities per unit face area of topsheet 34 and that portion of substrate 33 which lies above insert 35. With reference to the combination of topsheet 34 and absorbent body 33 materials, insert 35 should be placed so that the absorptive capacity per unit face area of the hydrophobic topsheet 34 at the maximum compressive stress normally encountered in use equals or exceeds the change in fluid retention capacity per unit face area of that portion of absorbent body 33 which is above insert 35 over the range of compressive stress in use. The determination of these parameters and materials discussed above in connection with the embodiments of Figures 1—7 apply equally here. A specific example of the Figure 8 structure is a diaper wherein the substrate 33 is made of creped cellulose wadding and topsheet 34 is made of a single ply of non-woven rayon, both of which are described above in connection with Figure 5, and a single ply of wadding lies between topsheet 34 and insert 35.

The topsheet 34 can be secured to the hydrophilic substrate 33 in a manner similar to that in which topsheet 21 is secured to substrate 20 in Figure 5. Similarly, back sheet 36 can be secured to the underturned portions of topsheet 34 to provide an envelope around substrate 33 as also described above in connection with Fig. 5.

The invention described above can be embodied in any of the rectangular pad forms described above and applied in the usual manner for rectangular diapers. The present invention, however, is also particularly useful when embodied in a box pleat configuration as shown by Figures 9—11. As described in British Patent Specification 1011888, the box pleat structure shown by Figures 9—11 provides a diaper which will effectively prevent leakage of an infant's waste fluids from the diaper and thereby substantially eliminate the problem of soiling of clothing. In view of the improved retention of fluids with such a box-pleat structure, it becomes advantageous to use the box-pleat structure to promote efficient use of the absorptive material in the diaper of the present invention and to promote dryness of the surface adjacent the base of the infant's trunk. The present invention when embodied in the box pleat diaper structure will provide this improvement to that structure. It also provides a structure which is more comfortable and better fitting when the central section is reduced in thickness to some extent.

Details of the box pleat structure are fully described in British Patent Specification 1011888 the disclosure of which is hereby incorporated by reference. However, Figures 9—11 and the accompanying explanation are herein included to illustrate the embodiment of the present invention in such a structure.

Figures 9 and 10 illustrate the Figure 8 embodiment prefolded into the box pleat structure. As shown in Figure 9, the pad 33a and backsheet 36 structure is folded at a first pair of folds 38 and then at a second pair of folds 39 to provide a pair of oppositely disposed inside panels B and E overlying central panel C (the panels B and E not overlapping but, rather, juxtaposed or slightly spaced at their inner ends 39) and a pair of outwardly facing terminal panels A and D overlying inside panels B and E respectively, whereby each of the terminal panels A and D has an outer side edge 40. The respective panels are not secured to each other at the ends of the pad so that the pad will be freely laterally spreadable; however, panels B and E can, if desired, be spot glued to panel C at the pad's center to facilitate application of the diaper to an infant. The spots of adhesive so applied, as is explained in the Duncan et al. patent, maintain the pad in a prefolded configuration at its centre while allowing the ends to be spread around the infant's waist.

Figure 11 shows the interior of the prefolded diaper of Figures 9 and 10 with the ends spread outwardly in preparation for the application of the diaper to an infant. In use, the ends of the diaper are spread, as shown, to go around the waist of the infant, the centre of the diaper remaining folded where the diaper passes between the infant's legs, and the overlap of the end portions of panels A and D, when the diaper is fastened, defining the leg openings. After the diaper is applied to the infant, its pleated construction and the child's natural movements cause the side edges of the pleat in the diaper crotch area to become bent downwardly. When this happens the flaps 36a, which comprise portions of the back sheet 36 which are folded over panels A and D, assume a position contiguous to the infant's legs along an area of the inner, rear and front portions of the thighs adjacent the junction thereof with the child's torso. In this position, the flaps are very effective in preventing or minimizing leakage from the diaper. When the diaper is constructed in accordance with the present invention, as by incorporating insert 35 in its central portion, the ability of the box pleat structure described in retaining fluids within the diaper is supplemented by the propensity of the present invention to promote surface dryness in the central section and wicking of waste fluids to the diaper's extremities. The latter function thereby reduces the total fluid in the diaper's central section which is available to reflood the topsheet 34 under in-use compressive stresses.

Example I

To substantiate the surface dryness qualities of the present invention, a test was run, the object of which was to determine the amount of moisture retained in the centre section of three different diaper samples. Sample 1 was a diaper having a uniform thickness of five plies of creped cellulose wadding underlying a hydrophobic topsheet. Sample 2 was a diaper having an identical hydrophobic topsheet and a thin centre section comprising one ply of creped cellulose wadding and end sections comprising seven plies of creped cellulost wadding. Sample 3 was a diaper having an identical hydrophobic topsheet and a thick center section comprising nine plies of creped cellulose wadding and three plies on the ends and sides. The type of dry wadding in each of the sample diapers was identical and cumulatively weighed about 24 grams, and each was wet at its centre by pouring roughly 50 grams of water into the diaper. The three diapers were laid paralled to and upon each other in order, the centre portion of the combined diapers was then systematically worked and squeezed with the hands to simulate in-use stresses, the order being changed (1, 2, 3 became 3, 1, 2 and finally 2, 3, 1) to equalize localized stresses. Indentically sized areas comprising the central portions of the diapers were then squeezed under like pressures and the amount of water squeezed therefrom weighed. Results are tabulated below.

Sample	Dry Wadding Weight	H_2O added	H_2O removed
1	24.06 g.	49.31 g.	2.67 g.
2	24.06 g.	49.04 g.	1.36 g.
3	23.92 g.	49.26 g.	6.89 g.

From the results tabulated, it is apparent that a substantial part of the moisture added was wicked to the extremities of the diapers having thin center sections as compared to that having a heavier center section.

Example II

A group of twelve sample topsheet substrate combinations was prepared, the twelve samples comprising three identical samples of each of four different structures (designated N, R, S and T). The samples were paired in the pattern N—R, N—S, N—T, R—S, R—T, S—T and were wet by adding water to the centre of each sample and allowing the sample at least 5 minutes in which to absorb the water. Except when being tested, samples were kept under polyethylene to minimize evaporation. Each sample of a given sturcture was wet identically with other samples having the same structure. The structures of the samples, weight of wadding in each structure, and the amount of water added to each structure as a multiple of the wadding weight are tabulated below.

Sample Designation	Structure: Ends and Sides[1])	Structure: Center[1])	Structure: Top Sheet[2])	Average Wadding Weight	Grams of Water Added (As Multiple of Wadding Weight)	Total
N	7 plies wadding	1 ply wadding	Dexter #X—1496-2	5.67 g.	3.0	17.0 g.
R	5 plies wadding	5 plies wadding	Dexter #X—1496-2	5.65 g.	3.0	17.0 g.
S	5 plies wadding	1 ply wadding	Dexter #X—1496-2	4.15 g.	4.1	16.6 g.
T	5 plies wadding	5 plies wadding	Dexter X—1364-2	5.54 g.	3.0	17.0 g.

[1]) The wadding was a creped cellulose wadding as hereinbefore described.

[2]) The topsheets used were of rayon and an acrylic binder. The designations are designations of C. H. Dexter and Sons Company to indicate two different topsheet compositions. X—1496-2 is approximately .9 mil thicker than X—1364-2 and is somewhat more hydrophobic.

Each pair of samples was then touched and felt in the centre by each of twelve panelists and their impressions of surface dryness were recorded according to a 0 to 4 grading scale wherein 0 means a particular pair of samples exhibit equivalent surface dryness, 1 means that one of a pair of samples is to a low degree of confidence somewhat drier than its opposite, 2 means that one of a pair of samples is to a high degree of confidence somewhat drier than its opposite, 3 means that one of a pair of samples is considerably drier than its opposite, and 4 means that one of a pair of samples is much drier than its opposite.

The scores as outlined above were then statistically manipulated to minimize effects due to differences in human sensitivity and the tendencies of panelists to be biased according to the order in which the samples were touched or for other reasons. The result of the statistical manipulation was a group of overall scores for the four structures wherein the structure designated N was taken as the standard and given a score of zero, i.e., each of structures R, S and T was scored relative to structure N. The scores thus derived were negative numbers indicating that structures R, S and T exhibited wetter surfaces than that of structure N according to the scoring system explained above. The net scores are tabulated below:

Sample Designation	Net Score
N	0 (base)
R	−2.39 "yardsticks"
S	−2.72 "
T	−3.49 "

A net score difference of 1.0 yardsticks represents a difference which is statistically significant at a 95% level of confidence. A difference less than 1.0 yardsticks indicates that no significant difference exists between samples at the 95% confidence level. A difference of 2.39 yardsticks indicates a clearly significant difference at the 95% level of confidence. For purposes of substantiating the efficacy of the present invention, comparison of the scores of structures N and R is the relevant comparison inasmuch as the samples having the N and R structures had almost equal wadding weights, were wet with equal amounts of water, and had identical topsheets. The other structures and wetting were included to obtain a broader sample base for the purpose of improving statistical validity of the data obtained. As indicated by the tabulation above, a diaper having a hydrophobic topsheet and center section with an absorptive capacity which is low relative to that of the remainder of the diaper will have a drier surface than a diaper with a uniform basis weight substrate.

WHAT WE CLAIM IS:—

1. A diaper comprising a top sheet for placing adjacent an infants skin, an absorbent body having a length and width enabling it to be applied to the lower portion of the torso of a child,, said absorbent body having end sections adaptable to embrace the waist and cover adjacent abdominal and back areas of the child, said absorbent body having end sections between the childs legs substantially throughout their normal range of movement, said absorbent body being continuous throughout its length and having, throughout a portion of its central section extending over at least 70% of the width of the absorbent body, an unstressed absorptive capacity per unit face area which is lower than the average unstressed absorptive capacity per unit face area in other portions of said absorbent body.

2. A diaper according to claim 1 wherein the central section is of substantially uniform unstressed absorptive capacity throughout its area.

3 A diaper according to claim 1 wherein the length of the central section is 30—45% of the total length of the absorbent body and the distance between one end of the central section and an adjacent end of the absorbent body is substantially 25% of the length of the absorbent body.

4. A diaper having a length and width adapted to be applied to the lower portion of the torso of a child, said diaper having end sections adapted to embrace the waist and cover adjacent abdominal and back areas of the child and a central section adapted to lie between the childs legs substantially throughout their normal range of movement, said diaper comprising a pad formed into a box pleat configuration by means of a multiplicity of longitudinal folds, said folds being unsecured at the ends of said pad whereby the pad is freely laterally spreadable at said ends, said box pleat configuration including a central panel, a pair of oppositely disposed inside panels connected to the sides of said central panel and folded in non-overlapping relationship with one another over one face of said central panel with the inner sides of said inside panels juxtaposed, and a pair of outwardly facing terminal panels overlying said inside panels, each of said terminal panels having an outer side edge which comprises a free edge of said pad; said pad being continuous from end to end and comprising an absorbent body, a porous topsheet overlying one major surface of the absorbent body and secured thereto, said absorbent body having in the interior of its central section an average unstressed absorptive capacity per unit face area which is lower than the average unstressed absorptive capacity per unit face area in other portions of said absorbent body, said interior of said central section comprising at least 70% of the width of said absorptnt body; said diaper including a thin waterproof back sheet on the side of the absorbent body which is remote from said topsheet, which back sheet has a width exceeding that of the said pad so as to provide oppositely disposed side flaps which are folded inwardly to enclose the side edges of said pad and overlie a portion of said terminal panels.

5. A diaper according to any of claims 1

to 4 wherein said topsheet is hydrophobic and has free space available for fluid retention per unit face area when subjected to a compressive stress of about 3 pounds per square inch which exceeds the change in absorptive capacity per unit face area in the central section of said absorbent body occurring when the compressive stress thereon changes from about 0.1 to about 3 pounds per square inch.

6. A diaper according to claim 5 wherein said absorbent body comprises a compressible material and the interior of said central section is permanently compressed to give a free space content in the interior which is about 85% to 95% of its total volume.

7. A diaper according to claim 6 wherein said compressible material is highly creped cellulose wadding, airlaid felt of pulp fibres, or a mixture thereof.

8. A diaper according to any of claims 1—7 wherein said absorbent body of material includes a thin sheet of water-impervious material extending the length of the said central section and the major portion of the width of the said absorbent body, said sheet being located between the two major surfaces of said absorbent body.

9. A diaper according to any of claims 1—8 wherein the topsheet is hydrophobic.

10. A diaper according to any of claims 1—9 wherein said absorbent body comprises a plurality of layers of absorbent material, the interior of said central section comprising at least one layer of said absorbent material and the other said portions of the absorbent body contiguous to said central section comprising a plurality of other layers of absorbent material which are cumulatively thicker than the absorbent material in the interior of said central section.

11. A diaper according to claim 10 wherein the said one layer of absorbent material extends the length and substantially the breadth of said absorbent body and has a small capillary size and low compressibility relative to the capillary size and compressibility of the material comprising the said other portions of the absorbent body contiguous to the central section thereof.

12. A diaper according to claim 11 wherein the said one layer of absorbent material is low creped tissue having a basis weight of about ten pounds per 3,000 square feet creped at 12% to 18% and the other layers of said absorbent material are selected from highly creped cellulose wadding having a basis weight of between about 9 to 28 pounds per 3,000 square feet, an airlaid felt comprising air-deposited pulp fibres, or mixtures thereof.

13. A diaper according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

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Fig. 1

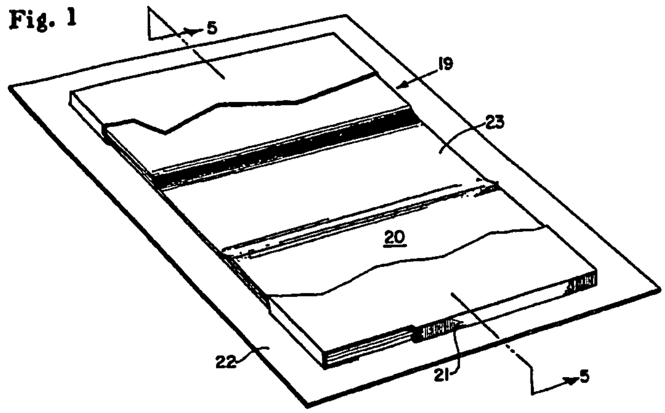


Fig. 2

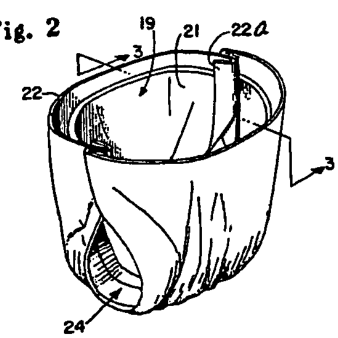
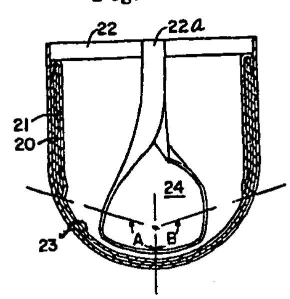


Fig. 3



1307441 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

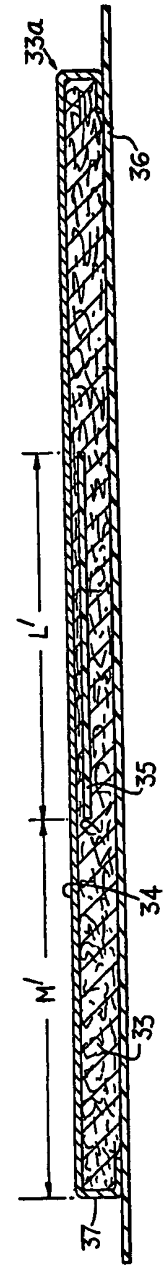
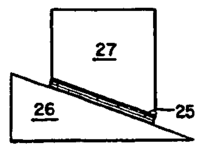


Fig. 8.

Fig. 4



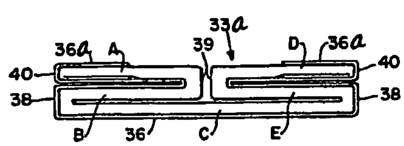


Fig. 9

1307441 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

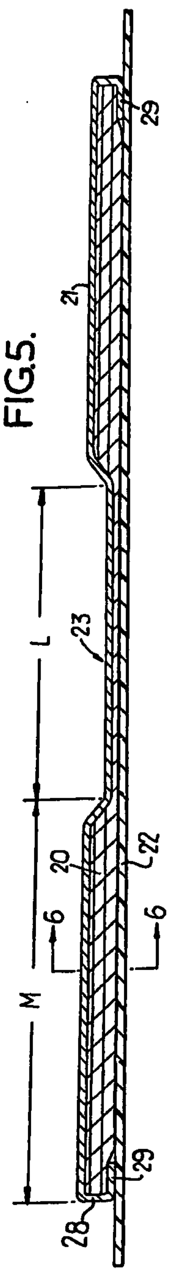


FIG.5.

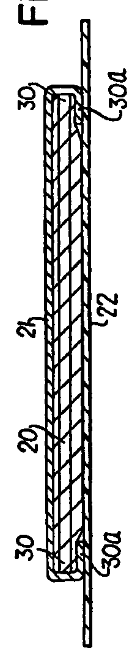


FIG.6.

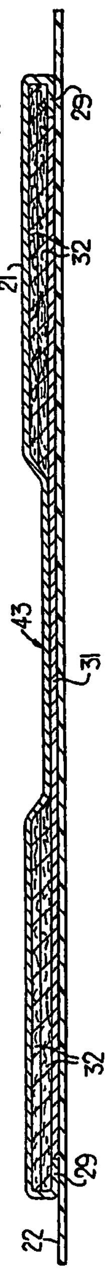


FIG.7.

Fig. 10

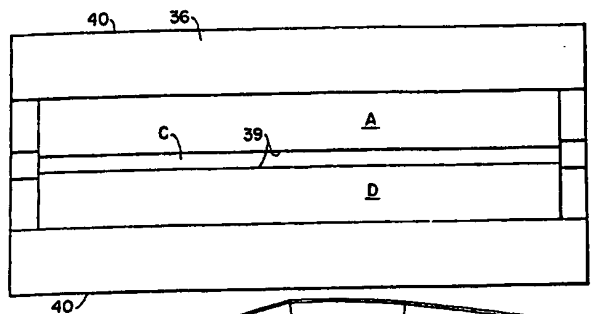


Fig. 11